PUBLIC HEALTH ASSESSMENT

Public Comment Release

RIVERFRONT
(a/k/a NEW HAVEN PUBLIC WATER SUPPLY SITE)
NEW HAVEN, FRANKLIN COUNTY, MISSOURI
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Section for Environmental Public Health
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Agency for Toxic Substances and Disease Registry

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SUMMARY

The Riverfront site, also known as the New Haven Public Water Supply site, consists of multiple plumes of tetrachloroethylene (PCE) - contaminated groundwater that underlie portions of the city of New Haven, Franklin County, Missouri. The contamination consists mostly of PCE, but also includes its degradation products. PCE contamination was first detected in New Haven's municipal well No. 2 on June 30, 1986, by the Missouri Department of Natural Resources (MDNR) at 28.2 parts per billion (ppb). This is above the U.S. Environmental Protection Agency's (EPA) Maximum Contaminant Level (MCL) of 5 ppb. The MCL is the highest level of a contaminant that EPA allows in public drinking water. City well No. 1 was also affected by PCE, but not at the levels detected in well No. 2. However, because well No.1 had a history of bacterial contamination, it was closed in 1989. The PCE contamination affected the town's municipal water supply until the installation of new wells and closure of well No. 2 (approximately 1993). Because contamination remains in the area groundwater, people could be affected if these new wells become contaminated. The EPA EXIT proposed the site for its National Priorities List (NPL) on July 27, 2000, because of the presence of these contamination plumes. The site was officially listed as an NPL site on December 1, 2000.

PCE is a volatile organic compound (VOC) that evaporates easily in air, but remains in soil and groundwater without much decomposition. Since it is heavier than water it can easily travel through soil and into the groundwater. PCE is a synthetic chemical that is widely used for dry cleaning, metal-degreasing, starting material for making other chemicals, and in some consumer products.

Based on information gathered during site investigations to date, several sources for the PCE contamination have been identified. PCE has been found in soil and groundwater samples collected near two manufacturing facilities known to have used PCE. However, due to the presence of other potential contributors and the complex hydrogeology in the area, the PCE detected in the municipal wells cannot be definitely attributed to either of these facilities. During one of the sampling events, water from potable outlets near the downtown industry was found contaminated with PCE. The black plastic polyethylene pipe that fed the water outlets was permeable to organic vapors, such as PCE, and had picked up the contamination from the highly contaminated nearby soils. EPA replaced the waterline with non-permeable pipe and removed contaminated soils through a removal action that eliminated PCE contamination at the water outlets.

Use of contaminated municipal water (municipal well No. 1 and No. 2) in the past by New Haven residents represents a completed exposure pathway. Outside of the public water supply area, a plume of PCE-contaminated groundwater has also affected some private drinking water wells. Until approximately 1999, no data were collected from private wells outside the city of New Haven. These private wells represent known completed exposure pathways for the past, but recent removal actions have eliminated that exposure. Because the PCE contamination remains in the groundwater at the Riverfront site, it is possible for people to be exposed in the present and future if the PCE contamination continues to move and affect additional existing private wells or new wells that are drilled into the contaminated aquifer. Finally, there remains the potential for city wells No. 3 and No. 4 to become contaminated in the future.

Completed exposure pathways in the past to PCE-contaminated drinking water have occurred for residents

using the New Haven public water supply before 1993 and, more recently, for some private well users. Currently, there is no known exposure to groundwater with concentrations of PCE above the MCL. Because no health guidelines exist to determine the health effects from low-level, long-term exposure to PCE, calculations were conducted to estimate the worst-case risk from ingestion and inhalation exposure for non-cancerous adverse health effects, as well as the risk of that exposure causing additional cancers in the population. Because calculations at these maximum levels and duration (which residents were not likely exposed to) indicated that no adverse non-cancerous health effects were likely to occur, and that only a slight theoretical additional cancer risk exists from these past exposures, and because no known exposure is currently occurring above the MCL, the Riverfront site has been classified as a No Apparent Public Health Hazard for the past and present. The category of No Apparent Public Health Hazard is used for sites where human exposure to a contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard.

For future conditions, the Riverfront site has been classified as an Indeterminate Public Health Hazard. The category of Indeterminate Public Health Hazard is assigned to sites for which no conclusions about the public health hazard can be made because data are lacking. This hazard classification is based on the following conclusions:

- Because high levels of PCE remain in groundwater and soil, there exists the potential for future exposures that could be at levels of health concern, especially for children and sensitive individuals and people working in contaminated areas.

- Limited data exist regarding the sources and locations of PCE contamination in the New Haven area. Because information is lacking about the various potential sources of the groundwater contamination and its movement, it is difficult to determine if future exposure to PCE-contaminated groundwater will occur.

- Levels of PCE detected in small surface streams should not pose a health concern unless the levels increase dramatically and/or the water is used for drinking.

- PCE in groundwater and subsurface soils may move up through the soil and into residences located on contaminated areas. Inhalation of volatilized PCE may be of health concern in the future.

- The possibility exists that black plastic polyethylene water lines may run through other PCE-contaminated areas and may be exposing residents who are supplied water through those waterlines.

- Surface soil (0-3 inches) in an area near the Wiser building has not been sampled, but subsurface soils (1.5 to 2.0 feet) contain elevated non-volatile contamination in an area where human recreational activities could be occurring.

For an explanation of terms and acronyms used in this document, refer to Appendix A.

PURPOSE AND HEALTH ISSUES

The Missouri Department of Health and Senior Services (DHSS), in cooperation with the federal Agency for Toxic Substances and Disease Registry (ATSDR), is evaluating the public health impact of the Riverfront

site. This public health assessment determines whether exposures at levels of health concern have occurred or are likely to occur, and recommends actions to reduce or prevent possible adverse health effects. ATSDR is a federal agency within the U.S. Department of Health and Human Services and is authorized by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) to conduct public health assessments at hazardous waste sites. This document assesses past, current, and future exposure to contamination at the Riverfront Site.

BACKGROUND AND STATEMENT OF ISSUES

Site Description and History

The Riverfront site consists of multiple plumes of tetrachloroethylene (PCE)-contaminated groundwater that underlie portions of the city of New Haven, Franklin County, Missouri. New Haven is a small town located on the southern bank of the Missouri River, approximately 50 miles west of St. Louis, on Missouri State Highway 100 (See Figure 1 in Appendix B). Several areas of subsurface soil contamination remain from the improper disposal or dumping of waste PCE. The contamination consists mostly of PCE, but also includes its degradation products trichloroethylene (TCE), cis-1,2-dichloroethylene, and vinyl chloride [all volatile organic compounds (VOCs)] with TCE being the most prominent degradation product. Because PCE is the most predominant and elevated contaminant, it is the focus of this document.

The Riverfront site was discovered after water sampling by the Missouri Department of Natural Resources (MDNR), on June 30, 1986, detected PCE in one of New Haven's two original city wells. The sampling discovered PCE levels above the Environmental Protection Agency's (EPA) Maximum Contaminant Level (MCL) of 5 parts per billion (ppb). The MCL is the highest level of a contaminant that EPA allows in public drinking water. PCE was detected in Municipal Well No. 1 at a maximum concentration of 21 ppb in December 1986, but levels were generally less than the MCL. Because the well also had a prior history of bacterial contamination, it was removed from service in 1989. PCE was also detected in New Haven Well No. 2, where concentrations have increased steadily over time (since sampling began in 1986) to a high of 140 ppb in 1993 when well No. 2 was removed from service. In 1988 and early 1994, two additional city wells (No. 3 and No. 4 respectively) were installed because of the closure of the other wells. These new wells were cased several hundred feet deeper with no contamination detected in them up to the present time (1,2,3).

Because of the contamination plume(s) that had affected the town's municipal water supply, EPA proposed the site for its National Priorities List (NPL) on July 27, 2000. The site was officially listed as an NPL site on December 01, 2000. Municipal water is presently supplied by two new uncontaminated wells. They are the only source of drinking water for the more than 1,800 residents of New Haven. These new wells could become contaminated with PCE (1,3,4).

From information gathered during the U.S. Geological Survey (USGS) Expanded Site Investigation/Remedial Investigation (RI) and the Focused RI of Operable Units OU1 and OU3, several sources for the PCE contamination have been identified (2,3). PCE has been found in soil and groundwater samples collected near two manufacturing facilities in the area that are known to have used PCE. However, due to the presence of other potential contributors and the complex hydrogeology in the area, the PCE detected in the municipal wells cannot be definitely attributed to either of these facilities.

Outside of the New Haven public water system, private wells provide drinking water to residents. Sampling of private wells for PCE contamination did not occur before 1999. Therefore, it is impossible to determine if people using private wells were exposed to PCE at levels above the MCL before 1999. South of the industrial park, a few private wells were recently found contaminated with PCE, but removal activities have eliminated that exposure. In the fall of 2002, MDNR, EPA, and USGS cooperatively released a well-drilling advisory for the area south of the industrial park and the northern plume area (south of the Missouri River) to inform well drillers of the PCE contamination.

Because several potential sources of PCE contamination have been identified, and because of the complex hydrogeology of the area, the site has been separated into six Operable Units (OUs) for investigation and accounting purposes (3,4) (See Figure 2 in Appendix B). They are:

- OU-1 - Front Street site (formerly known as "Riverfront", and consisting of the Wiser's property and surrounding area), approximately 2 acres in size.

- OU-2 - Industrial Drive site (Kellwood/Metalcraft area, former landfarming cleanup area, surrounding area, and sewer system), approximately 20 acres with the primary site about 7 acres.

- OU-3 - Old City Dump (off Highway 100). Used for the disposal of industrial and municipal waste in the past, more currently for the disposal of demolition and yard waste.

- OU-4 - Orchard Street (encompasses all areas south of Orchard St., north of Highway 100, east of Miller St., just west of the old city dump). This OU was formerly known as "East New Haven", and may consist of as many as 300 acres and the distribution lines for the sanitary sewer system.

- OU-5 - Hat Factory on Wall Street, approximately 3 acres with possible historical PCE use.

- OU-6 - consists of all removal actions addressing PCE contamination in private wells conducted south of OU-2, including residences on Boeuf Lutheran Road (OU-6 is not shown on Figure 2).

Contamination in OU-1:

The Front Street site (OU-1) is located in the eastern part of downtown New Haven (See Figure 1 in Appendix A). This OU has the largest concentration of PCE and its degradation products in subsurface soil and groundwater. The principle feature of the site is a one-story building (Wiser property) that was used from the mid-1950s through the early 1970s for a variety of industrial activities including metal fabrication, furniture assembly and painting, metal tempering, and automobile repair. Large quantities of PCE were used during that time and PCE-contaminated waste was reportedly dumped on the land surface near the building. Beneath the site, Missouri River alluvium averages between 30-40 feet in depth (2, 3).

In May 2000, water at an outdoor faucet on Front Street, that provided water to the city's animal shelter, and the sink faucet at the Missouri Department of Conservation Missouri River access public restroom were found to be contaminated with PCE up to a maximum level of 2,212 ppb. The black plastic polyethylene waterline that supplied these two outlets with city water ran beneath Front Street and adjacent to the Wiser property where soils were highly contaminated with PCE. This type of waterline is permeable to organic vapors, such as PCE, and is believed to have picked up the PCE contamination from the nearby-contaminated soils. Sampling determined that only this particular water line and the two water outlets had been affected. In July and August 2000, EPA conducted an emergency removal action during which they removed the contaminated water line and PCE-contaminated soils from in front of the Wiser building. Contamination levels ranged from 10 to 6,200,000 ppb PCE. A total of 763 tons of contaminated soil was excavated to a maximum depth of 8 feet in certain sampling grids and disposed of at a CERCLA-approved landfill. The waterline was replaced with iron water pipe with chemical resistant gaskets to prevent recontamination of the water line (2,3,5,6,7). The removal action eliminated exposure at the two water outlets.

Further sampling and laboratory analyses of subsurface soil has found that PCE contamination, up to a maximum of 2,200,000 ppb (8.5 feet deep), still remains in subsurface soils around the Wiser facility (2,3).

Maximum levels detected in laboratory analyses of the degradation products (TCE, cis-1,2-dichloroethylene, and vinyl chloride) in the subsurface soils are below ATSDR health comparison values. ATSDR health comparison values are media-specific concentrations that are used by health assessors to select environmental contaminants for further evaluation. Contaminant levels below a comparison value are not expected to pose a health threat. All of the surface soil samples were taken from the 0 to 2 foot range and are not representative of what ATSDR considers surface soil samples. ATSDR considers surface soils to be between 0 to 3 inches deep where activity with the soil is most likely to occur. Considering that the PCE was dumped until around 1972 (approximately 31 years ago), and that VOCs readily evaporate when exposed to air at or near the soil surface, it is not expected that VOC levels of health concern remain in surface soils (0-3 inches).

In an area across from the Wiser building, elevated levels of lead and polycyclic aromatic hydrocarbons (PAHs) were detected in subsurface soil at the 1.5 to 2.0 foot depth (3,6). Although no exposure to the contaminants is expected at this depth (except for people digging in the soil), there is evidence that human recreational activities have taken place near the location of this sample. Since no surface soil samples (0-3 inches) were taken, we are not able to determine if the human exposure that has occurred or may be occurring might be of a health concern.

The maximum level of PCE in groundwater was found underneath the Wiser building at 6,100 ppb. Groundwater is expected to be moving north toward the Missouri River. PCE contamination was detected at 670 ppb in a monitoring well close to the river. Samples taken of the Missouri River water and sediment detected no PCE or other VOCs. A hand-dug well located near the Wiser facility (not used for drinking purposes) contained a maximum of 376 ppb PCE (2,3).

Two private residences are located adjacent to and north of the facility. One residence partly overlies the plume, while the other residence completely overlies the contamination plume. To determine if PCE or other VOCs from the groundwater plume were infiltrating into the residences, indoor air sampling was performed in September 2002 on the residence that is partially above the plume. Results indicated that VOCs were not present at a level of health concern (8). Indoor air sampling for the residence that completely overlies the plume was done in May 2003. PCE was detected at 87 ppb, above ATSDR's chronic minimum risk level (MRL) of 40 ppb (9). After the contents of the basement were removed, another round of air sampling was performed in July 2003. PCE levels in the basement and living room were found at a maximum of 4.27 ppb, below the chronic MRL (10).

A former dry cleaning facility was also investigated during the OU-1 characterization, but soil sampling did not detect any contamination at that location (11). Also located in the downtown New Haven area, but outside of the OU-1 area, is an industrial well at a fertilizer plant where 10 ppb of PCE was detected in a one-time sampling (2,3). The industrial well is not shown in the figures, but is located west and just across the street from city well No. 1.

Contamination in OU-2:

The Kellwood/Metalcraft site (OU-2) is located near the south end of Industrial Drive in the southern part of New Haven (See Figure 2). The site consists of a privately owned manufacturing building and a 1-acre vacant lot, north of the manufacturing building. The EPA and MDNR have determined that PCE was used as a cleaning solvent for metal cutting and metal tubing fabrication processes. The PCE was then disposed of on the 1-acre lot and dumped into the sanitary sewer system. The former building owner attempted a cleanup of PCE contaminated soils on the lot north of the building in 1990 by landfarming (incorporation of waste into soil for decomposition). The site lies south of a groundwater divide and is not expected to have been a source of contamination for city well No. 1 or 2, but has affected private wells south of OU-2 and may threaten the presently uncontaminated city well No. 3, which is located less than 1,000 feet north of the site (2,6).

Soil contamination in the 1-acre landfarming area was found to be variable with levels ranging from non-detectable up to 3,300 ppb in subsurface soils (1 to 2 feet). Groundwater sampling around the landfarm area found shallow groundwater (5 to 50 feet) contaminated with PCE ranging from 1,000 to 200,000 ppb with a

questionable sample indicating seven times that value. Deep groundwater monitoring wells have not indicated any contamination (2,6).

A shallow PCE-contaminated groundwater plume has also been found south of the Kellwood property. It extends for more than 4,000 feet and has affected private wells and surface water. The affected private wells are further discussed under Contamination in OU-6. Shallow monitoring wells have contamination in them, while deeper monitoring wells do not, indicating that the plume is moving at depths less than 160 feet (12).

PCE was also found in a small creek that drains OU-2 and the surrounding area at levels up to 58 ppb, but the levels decreased downstream until it was undetectable (3,6). More recent sampling in 2002 found PCE at 100 ppb and TCE at 11 ppb in the stream that drains OU-2 (13). The water is not used for drinking and access is limited. Activities, such as children playing in the water, should be avoided. The sanitary sewer was also sampled in a number of locations in OU-2 and found to have the highest levels of contamination near the plant at 17 ppb. The levels decreased as water samples were taken farther away from the facility (2,6).

Contamination in OU-3:

The old New Haven City Dump (OU-3) consists of a 1.5-acre lot adjacent to Missouri Highway 100 in the southeast part of New Haven (See Figure 2). The dump was originally under private ownership and was created by filling in a ravine and is approximately 320 feet wide and 200 feet long. The surface of the dump is level until it steeply drops off on the northern end to the ravine floor, approximately 35 feet below. Hundreds of drums of industrial waste including dyes, flammable solvents, waterproofing compounds and other waste materials were reportedly placed in the dump. The liquids were routinely burned in a pit. The city of New Haven purchased the dump in 1972 and used it for the disposal of demolition and yard waste. Water sampling conducted at the dump from 1999 thru 2001 included analysis of several seeps and a single bedrock monitoring well. PCE contamination was only found in one of the seep samples at trace concentrations, with other VOCs not being detected (2,3,6). The seeps are not used as a drinking water source and are relatively inaccessible, so human exposure is not expected.

Industrial waste, expected to be similar to that found in the dump, was discovered on private land near the dump. The waste was sampled and found not to contain PCE or other chlorinated solvents, but was found to contain ethylbenzene, toluene, xylenes, lead, and chromium. The landowner initiated a cleanup of the waste in 2000 (2,3,6).

Resampling of the dump seeps, monitoring well, and private wells around the dump was done in 2003. Also, an additional monitoring well was installed down gradient from the dump to better determine if groundwater was being affected. Results of sampling and potential exposure at the landfill are addressed in a DHSS/ATSDR health consultation released September 30, 2003. The health consultation determined that at present the dump presented no public health hazard, but did recommend that a long-term monitoring plan be implemented and that institutional controls be put in place restricting well drilling in and down gradient of the dump. DHSS/ATSDR also released a health consultation for the water sampling data of private wells around the landfill on September 30, 2003. The health consultation determined that no public health hazard existed to persons using potable water from the private wells located around the dump, but also recommended that if the dump was found to be affecting groundwater, a long-term private well monitoring program should be initiated.

Contamination in OU-4:

The East New Haven site (OU-4) consists of an undeveloped area of overgrown fields, ravines, and woods south of Orchard Street (See Figure 2). The site is located approximately between the old city dump and downtown New Haven. The area was designated as an operable unit because of the detection of PCE concentrations (range of 148 to 289 ppb) in deep groundwater from bedrock monitoring wells south of and up gradient from city well No. 2. Concentrations of PCE have also been detected in a segment of a small stream that drains the area at a maximum of 20.7 ppb at the upper end with decreasing levels downstream (2,5,6).

Further investigation and sampling, including a round of indoor air sampling at a residence where waste PCE was spread as weed killer, is on going.

Contamination in OU-5:

Investigation of the old hat factory (OU-5) has only recently begun as a potential source of the PCE contamination (See Figure 2). A review of February 2002 soil sampling data taken from varying depths (0.5 to 1 foot, 2 to 2.5 feet, and 6.5 to 7.0 feet) did not indicate that any PCE was present. Groundwater sampling in April 2002 from a monitoring well at the old hat factory did find that the groundwater was contaminated with 140 ppb of PCE (14). Further investigation is planned for this operable unit.

Contamination in OU-6:

OU-6 has no specific boundary, but is generally located south of OU-2 and consists of all removal actions addressing PCE contamination in private wells south of OU-2. Presently, only four private wells around OU-2 have been found to have detectable levels of PCE since sampling was first begun in 1999. PCE levels ranged from 1.4 ppb to 210 ppb (15). After discussions between EPA, DHSS, and ATSDR personnel concerning the best method to eliminate all routes of exposure at the residence with the most contaminated well, DHSS/ATSDR released a health consultation on February 13, 2002, stating that whole-house filtration was the best choice for removal of PCE from contaminated private wells and would eliminate all routes of exposure. To eliminate exposure at these residences, the potentially responsible party (PRP) for the contamination at OU-2 (which has affected these private wells) has provided either whole-house filtration systems, attached them to public water, or cased their well deeper to cut off the contamination (Personal conversation with PRP representative, 2003 April 1). Because contaminated groundwater remains and the area of contaminated groundwater may continue to expand, other private wells in the area south of OU-2 also have the potential to become contaminated.

Site Visit and Public Meetings

On May 3, 2002, DHSS and USGS personnel conducted a site visit of the Riverfront site and discussed past and recent developments that had taken place at the site. DHSS and other involved agencies have provided site and health information to the public in additional meetings. Health concerns raised by the residents of New Haven at a February 22, 2001, public meeting are addressed in the Community Health Concerns section.

On October 30, 2003, DHSS held a public availability session in New Haven to present the public comment version of the Riverfront Public Health Assessment to the public and to gather and discuss any additional concerns the public might have.

Natural Resources and Geology

The city of New Haven was founded in 1836 and is located on the southern bank of the Missouri River. Most of the city is located along and south of the steep river bluff that overlooks a downtown business district adjacent to the Missouri River. The downtown business district is located within a narrow strip of floodplain and consists of small businesses, a few homes, several small old manufacturing buildings, a Missouri Department of Conservation (MDC) Missouri River access and the New Haven city park. This area of New Haven is surrounded by a flood protection levee that is maintained by the U.S. Army Corps of Engineers and is also the location of OU-1. Land use south of the river bluff is mostly residential with an industrial park (location of OU-2) containing several large manufacturing facilities further south across Missouri State Highway 100 (See Figure 1). Land-use outside of the city is agricultural, consisting mostly of pasture with some row crops (5).

The MDC Missouri River access and the city park area are used by fishermen, boaters, and visitors and is the busiest on weekends (Telephone conversation with MDC personnel, 2002 May 30). There is at least one major annual festival in the downtown area. Exposure to underground contaminants is not expected to occur

to users of the area, especially after the emergency removal of the contaminated waterline to the MDC public restroom. Some brief, infrequent exposure may have occurred to the PCE-contaminated water at the MDC restroom, but no adverse health effects are expected from that exposure.

Bedrock units of the Ozark aquifer underlie New Haven. The Ozark aquifer is a thick sequence of water-bearing dolostone, limestone, and sandstone formations ranging in age from Late Cambrian to Middle Devonian. Although these formations collectively act as a regional aquifer with flow systems extending tens of miles, the water-yielding capacity of the individual formations is variable. The shallow aquifer extends to about 400-500 feet deep, while the deep aquifer extends from depths of 500-600 feet to more than 1,000 feet deep. New Haven city wells No. 1 and No. 2 are cased less than 225 feet deep and are open to a bedrock unit known as the Roubidoux Formation. This formation is probably the most widely used formation in south-central Missouri for domestic wells. The uncontaminated city wells No. 3 and No. 4 are cased deeper (525 and 560 feet) through the Roubidoux Formation (3,5).

In an effort to determine the extent of the PCE contamination in the vicinity of New Haven, the USGS conducted a well inventory in the New Haven area. The primary objectives of this inventory were to determine if a shallow groundwater divide existed in the southern part of the city, and to develop an understanding of groundwater flow and quality in the area. Of the 67 inventoried wells, water-level measurements were obtained from 56 and water samples were collected and analyzed from 53.

The results of the well inventory found the existence of a shallow groundwater divide centered along State Highway 100 just south of the topographic (surface) divide. Shallow groundwater flows from this topographic high toward discharge areas along Boeuf Creek to the south and the Missouri River to the north. However, regional groundwater flow is north toward the Missouri River. In addition to the shallow groundwater divide, this area is considered to have some characteristics of Karst geology in the upper bedrock (e.g., caves,sinkholes, gaining and losing streams, and fractured rock structures). This complex hydrogeological system makes it difficult at best to determine the source and flow pathways of PCE contamination in the area (3,5).

Demographics

Demographics for the city of New Haven were compiled from 2000 U.S. Census Data. In 2000, the population of New Haven was 1,867, with 98.0% white, 0.6% black, and 0.3% American Indian and Alaska Native. The remaining 1.1% was identified as two or more races. In 2000, there were 149 children under age 5 living in the city. In addition, there were 318 citizens over age 65. The median household income for the area in 2000 was $36,681. In 1999, 13 families lived below the poverty level. In 1999, of the 713 households in the city, 16 households received Public Assistance and 245 households received Social Security income (16). In general, this area represents a white, working-class community in a semi-rural area of Franklin County.

DISCUSSION

Pathways Analysis

To determine whether the residents of New Haven are exposed to contaminants at this site, DHSS evaluated the environmental and human components that lead to an exposure pathway. An exposure pathway consists of five elements that ATSDR considers necessary for a completed exposure pathway. The five elements are a source of contamination, transport through an environmental medium, a point of exposure, a route of human exposure, and a receptor population. An exposure pathway can be eliminated if at least one of the five elements is missing and will never be present. Completed exposure pathways exist when the five elements of a pathway link the contaminant source to a receptor population. Potential exposure pathways, however, have at least one of the five elements missing or uncertain, but could exist. Completed and potential exposure

pathways could have occurred in the past, could be presently occurring, or could occur in the future (17). Pathways are summarized in Appendix C.

Completed Exposure Pathways

Past:

Completed exposure pathways existed at the Riverfront site until the contaminated public wells were taken off-line, and at some private wells until corrective measures were taken. The five elements of a completed exposure pathway at the Riverfront Site are listed below:

1. **Contaminant source** - past releases and improper disposal of PCE at several manufacturing facilities that have contaminated soil and groundwater.

2. **Environmental medium and transport** - PCE-contaminated groundwater and soil.

3. **Point of exposure** - public water system, private wells, soils, and surface water.

4. **Route of exposure** - ingestion, inhalation, and dermal contact.

5. **Exposed population** - public water and private well users and those who make contact with contaminated soils and surface water.

Although all of the potential sources of PCE contamination have not been determined at this time, severalsource areas have already been identified. Groundwater, soils, and surface water are contaminated with PCE. The point of exposure is individual households using the municipal water supply distribution system before 1993 or contaminated private wells. The exposed populations are those New Haven residents who used city water before 1993, and contaminated private well users. In the past, an exposure pathway for PCE was completed when residents used the contaminated municipal water supply or contaminated private wells. The estimated population exposed to contamination in this past-completed exposure pathway is more than 1,800. Table 1 in Appendix C illustrates the different exposure pathways present at the Riverfront site.

Present:

Presently no known completed exposure pathways exist above the MCL for public water users or private well users. The possibility does exist that the use of a contaminated industrial well could provide a completed exposure pathway to workers.

Potential Exposure Pathways

Past, present, and future potential exposure pathways exist to contaminated groundwater and subsurface soil. In the past, no data were collected regarding contamination in private wells outside the city of New Haven. Presently and in the future, additional private well users have the potential to be exposed to PCE if the contamination plume expands, especially south of OU-2. Also, residents have the potential to be exposed if new wells are drilled into contaminated sections of the aquifer. In addition, if in the future there is mixing of contaminated water between the contaminated shallow aquifer and the deeper aquifer (from which city wells No. 3 and No. 4 draw) the municipal water supply could become re-contaminated.

Vapors from the PCE contaminated groundwater plume at OU-1 could possibility infiltrate into residences that are situated above or near the plume. Residents living in those houses could potentially be exposed to

PCE contaminated indoor air in the future.

People being served by areas of the municipal water system containing black plastic polyethylene water lines which run through highly contaminated areas, also have the potential for exposures (similar to those that occurred at the MDC restrooms). In addition, at least two creeks/drainage ways are contaminated with PCE that people have the potential to come into contact with. Exposure is not really expected in the drainage way from OU-4, but the creek that drains OU-2 has the potential for children to play in.

Toxicological Evaluation

Introduction

This section will discuss the health effects of exposure to specific contaminants. To evaluate health effects, ATSDR has developed Minimal Risk Levels (MRL) for contaminants commonly found at hazardous waste sites. The MRL is an estimate of daily human exposure to a contaminant below which non-cancer, adverse health effects are unlikely to occur. Levels above an MRL do not mean that health effects will definitely occur. Rather, it calls for more investigation into whether health effects may occur. MRLs are developed for each route of exposure, such as ingestion and inhalation, and for the length of exposure, such as acute (less than 14 days), intermediate (15 to 364 days), and chronic (greater than 365 days). This toxicological evaluation section will discuss the possible adverse health effects from long-term exposure to low-levels of PCE contamination in drinking water. Since an MRL has not been developed for long-term, low-level oral exposure to PCE, calculations were done to estimate the amount of exposure that occurred to users of the New Haven public water system. The probabilities of PCE causing cancer and the theoretical risk of exposure to PCE causing additional cancers are discussed under the cancer section.

Tetrachloroethylene (PCE) (also known as perchloroethylene or perc)

PCE is a volatile organic compound (VOC) that evaporates easily in air, but stays in soil and groundwater without much decomposition. Because it is heavier than water it can easily travel through soil and into the groundwater. PCE is a synthetic chemical that is widely used for dry cleaning, metal-degreasing, starting material for making other chemicals, and in some consumer products. In air, PCE has a sharp, sweet odor, which most people can begin to smell at around 1,000 parts per billion (ppb) or more (18).

Toxicology

Exposure to PCE can be through ingestion, inhalation, and dermal contact. PCE that is inhaled is readily absorbed into the blood through the lungs. The amount of PCE that is absorbed is dependent on the concentration of PCE in the air, how fast and deeply one breathes, and how long one is exposed. When one ingests PCE contaminated water, most of the PCE will be absorbed into the bloodstream. A person will breathe out much of the PCE that is absorbed. A small percentage (1-3%) of the absorbed PCE will be converted into trichloroacetic acid (TCA) by the liver and excreted in urine within a few days. Some of the PCE in the blood will be stored in fat that later will be reabsorbed by the blood and exhaled. During this period of time nursing mothers can pass PCE on to their babies. PCE has also been shown to cross the placenta and distribute in the fetus. After exposure stops, the PCE stored in fat is the slowest to be eliminated (about one-half in an estimated 55 hours) and may take several days or weeks before it is completely eliminated (18).

The nervous system is a major target organ of PCE in humans by the inhalation route. At high concentrations it is known to produce loss of consciousness and has been safely used as a general anesthetic agent in the past. When concentrations in air are high - particularly in closed, poorly ventilated areas - single exposures can cause dizziness, headaches, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness, and death. Studies have shown that volunteers exposed to PCE at a concentration of 210,000 to 240,000 ppb for over 30 minutes reported a slight lightheadedness. Exposure to 100,000 ppb for seven hours produced headaches, dizziness, difficultly in speaking, and sleepiness. Mood changes, slight loss

of muscular coordination, faintness, and dizziness occurred with exposure at concentrations of 1,000,000 to 1,500,000 ppb for less than two hours. In industry, the Occupational Safety and Health Administration (OSHA) limits the amount of PCE in air that workers may be exposed to at 100,000 ppb [100 parts per million (ppm)] on a time weighted average (TWA), whereas the American Conference of Governmental Industrial Hygienist (ACGIH) has an advisory TWA value of 25,000 ppb (25 ppm). Exposure at low levels may also occur to families of PCE exposed workers from contaminated clothing and the absorbed PCE of the worker being slowly exhaled. Additionally, PCE may be slowly released from clothes that have been dry-cleaned with PCE (18).

Liver and kidney toxicity has been reported from acute exposures (short term) at very high doses. At lower levels, studies of volunteers were exposed to levels of PCE from 0 to 150,000 ppb for varying amount of time and another study with exposure levels of 0 to 100,000 ppb for 5.5 hours/day, 5 days a week, over an 11-week period. A complete panel of clinical chemistries found no deviations in pre-exposure and post-exposure value of liver functions. Weak or no kidney effects (depending on the parameters evaluated) were reported in people with chronic occupational exposure. A study did find that workers in dry cleaning shops exposed for an average of 14 years to an estimated TWA of 10,000 ppb did have increased levels of markers of early kidney damage that is suggestive of mild tubular damage (18).

Neurological effects or liver and kidney toxicity would not be expected from the level residents were exposed to at the site, but the health effects of breathing in air and drinking water with low levels of PCE are not definitely known.

Exposure (non-cancerous):

People can be exposed through ingestion by drinking contaminated water or eating food prepared with contaminated water. People can also be exposed to PCE through inhalation while showering, bathing, and washing clothes and dishes, as well as other household activities. Exposure through dermal contact can take place during showering, bathing, or other activities that put the skin in contact with PCE-contaminated water.

PCE exposure through inhalation, ingestion, and dermal contact has occurred, may still be occurring, and may occur in the future for some residents living in and around the city of New Haven. PCE has been detected above the MCL of 5 ppb in city wells No. 1 and No. 2 as early as 1986. Exposures to PCE from the municipal water supply continued until Well No. 2 was shut down in 1993 (2,3,5). Considering that PCE was first detected in 1986 slightly above the MCL, residents may have been exposed to PCE for at least 7 years. PCE contamination above the MCL in private drinking water wells has recently been discovered south of the city limits of New Haven. It is unknown how long these wells have been contaminated, because private well sampling was not conducted in the area around New Haven before 1999.

Ingestion Exposure:

Ingestion exposures were calculated using the worst-case exposure scenario for past exposures to contaminated water from the New Haven public water system. Because levels of PCE contamination were only measured sporadically and varied over time, the highest known concentration of 89 ppb PCE (found in public well No. 2) those residents may have been exposed to was used to calculate the worst-case exposure scenario. Based on the discovery of PCE contamination in the New Haven public wells in 1986, calculations were made using this maximum level for 7 years until the last contaminated public well was taken off line in 1993.

Users of private wells south of OU-2 were also exposed to PCE-contaminated drinking water, but the level and time of those exposures is less clear. To again consider the worst-case exposure scenario, it was assumed that the private well users were exposed to the maximum level detected (210 ppb) from the time that the Kellwood/Metalcraft industry first started cleanup of contaminated soils on their property (1990) until exposure ceased (2002). Residents using the public water system or private wells were not exposed to these levels for the full period of time, but these maximum levels and periods of time were used to calculate a

worst-case exposure scenario. These calculations make very conservative (protective) assumptions and may overestimate the exposure that occurred. The calculations can be found in Appendix D.

To calculate a dose, we assumed that adults, on average, drink 2 liters (66 ounces) of tap water each day and weigh 70 Kilograms (Kg) (154 pounds). For children, we assume that they drink 1 liter (33 ounces) of tap water each day and weigh 10 Kg (22 pounds) (18). The calculated dose for users of the public water supply in the past for adults was 0.0025 milligram (mg)/Kg/day, and for children was 0.0089 mg/Kg/day. The calculated dose for adult users of contaminated private wells in the past was 0.012 mg/Kg/day, and for children the dose was 0.042 mg/Kg/day. ATSDR has developed an MRL for acute-duration exposure of 0.05 mg/Kg/day, but have not derived an intermediate or chronic MRL. Since no chronic MRL has been determined, doses were compared to studies with known exposure doses. The doses for adults and children at this site did not exceed any No Observed Adverse Effect Level (NOAEL) in studies involving chronic exposures to PCE when those levels were adjusted for humans from animal studies. A NOAEL is a chemical-specific dose at which no adverse health effects were observed in the study subjects (18).

Inhalation Exposure and Total Exposure:

Because the user of a PCE-contaminated water supply would also have exposure through inhalation as PCE volatilizes into the air, inhalation exposure must be included as part of the total exposure. Most of this inhalation exposure takes place during and after showering as time spent in the bathroom as well as other household activities where PCE can volatize. Because no indoor air sampling was conducted to determine the levels of PCE that may have been present and to consider both pathways of exposure and their additive effect, we double (x 2) the ingestion exposure dose. The calculated total dose (ingestion and inhalation) from past exposure to the public water system for adults is 0.0050 mg/Kg/day, and 0.0178 mg/Kg/day for children. The total calculated past exposure dose for users of contaminated private wells for adults is 0.012 mg/Kg/day, and 0.042 mg/Kg/day for children. This gives us a total exposure dose that is a conservative (more protective) value that includes both pathways. These total doses do not exceed the MRL for acute-duration ingestion exposure of 0.05 mg/Kg/day. However, residents were exposed for a longer period of time. Therefore, because ATSDR has not developed an intermediate or chronic MRL, total doses were compared to studies with known exposures. The total doses for adults and children do not exceed any NOAEL in studies involving chronic exposures to PCE when those levels were adjusted from animal studies. Therefore, no adverse health effects are expected from ingestion and inhalation exposure at this site.

Dermal Contact:

Dermal effects of exposure to PCE are usually the consequence of direct skin contact with concentrated solutions in occupational settings. Absorption of PCE through the skin is considered a minor route of exposure. A study to determine the absorption of PCE through the skin found that only 1% of what would have been expected to be absorbed via inhalation was absorbed by the dermal route (18). Because of this low absorption through the skin and the low levels of PCE that were present in the New Haven public water supply, private wells, and contaminated streams, the dermal exposure pathway is considered negligible and is not expected to have any adverse health effects.

Cancer

The American Cancer Society estimates that in the United States, slightly less than half of all men and slightly more than one-third of all women will develop some form of cancer in their lifetime (19). The potential for PCE to cause cancer from ingestion and inhalation exposure is presently under review by the EPA, is classified by the International Agency for Research on Cancer (IARC) as probably carcinogenic to humans (limited human evidence, sufficient evidence in animals) and by National Toxicology Program (NTP) as reasonably anticipated to be a carcinogen. The carcinogenicity of PCE has been documented in animals exposed by inhalation or oral (18). The best summary of the cancer potential of PCE in humans is from ToxProbe: "There is no consensus in the scientific community and regulatory agencies with respect to whether tetrachloroethylene (PCE) induces cancer effects in humans" (20).

To determine the theoretical cancer risk for adults exposed to hazardous chemicals, EPA has developed cancer unit risk factors (Oral Slope Factor) for different chemicals. Because the carcinogenicity of PCE is presently under review and no EPA number is presently available, the past oral slope factor [0.052 $(mg/Kg/day)^{-1}$] is used for theoretical cancer calculations. This number will be used until EPA develops a revised oral slope factor number for PCE.

Cancer risks are calculated over a lifetime, estimated to be 70 years. DHSS calculated the cancer risk for the Riverfront site from the different exposure pathways associated with the site using the worst-case scenario (the maximum level of contamination residents were exposed to for the maximum amount of exposure time). Because of the conservative nature of these calculations, this approach provides a theoretical maximum estimated risk of cancer. In reality, the true or actual risk is unknown and could be as low as zero.

Cancer calculations for the Riverfront site are based on an exposure level of 89 ppb PCE in the public water system to which residents would have been exposed for a period of time. Considering that PCE was first discovered in the New Haven public water system in 1986, exposure to levels of PCE are expected to have occurred for 7 years. Additional cancer risks for adults using the public water system were 2.6×10^{-5} (or 26 additional cancers in a million people), and 9.3×10^{-5} for children (or 93 additional cancers in a million people). Cancer calculations were also completed for people who used contaminated private wells. For the calculations we assumed that residents were exposed to the maximum detected level (210 ppb) for 12 years. The additional theoretical cancer risks were calculated to be 1.1×10^{-4} for adults (or 110 additional cancers in a million people), and 3.7×10^{-4} for children (or 370 additional cancers in a million people). A child is considered a child for only six years, so this cancer risk calculation overestimates the child's cancer risk (12 years were used for the length of exposure). These calculations can be found in Appendix D.

Based on these theoretical calculations and the extremely conservative assumptions used in the calculations, DHSS/ATSDR does not believe there to be an elevated risk of developing cancer from the exposure to contaminated groundwater from the New Haven public water system or private wells.

Children and Other Sensitive Populations

A sensitive population will exhibit a different or enhanced response to hazardous chemicals than will most persons exposed to the same level of hazardous chemicals in the environment. Reasons for sensitivity might include genetic makeup, age, health and nutritional status, and exposure to other toxic substances. In general, the elderly, with declining organ function, and the young, with immature and developing organs, are more vulnerable to toxic substances than are healthy adults (18).

The developing fetus and young children, especially their developing nervous systems, may be particularly susceptible to the toxic effects of PCE. In animal studies, exposure to very high levels of PCE can be toxic to unborn pups of pregnant rats and mice. Changes in behavior were observed in the offspring of rats that breathed high levels of the chemical while they were pregnant. How PCE may affect the developing brains in human babies is not known. Infants can be exposed to PCE that has been transferred into breast milk, by inhalation of PCE that has been exhaled from someone previously exposed, or released from dry cleaned clothes. Therefore, because of both potential exposures and a sensitive and possibly permanent effect, infants should be considered a susceptible population for exposure to PCE (18).

Some adults appear to have increased sensitivity to high doses of PCE (e.g., cardiac sensitization). Since high doses of PCE are known to cause effects on the liver and kidney, persons with clinical or subclinical kidney or liver disease may be predisposed to the effects of PCE. People who abuse alcohol, or are treated with disulfiram (a drug used to treat chemical dependency) may be more susceptible to the toxic effects of PCE. Persons with pre-existing nervous system diseases also may be more sensitive to the neurologic effects of PCE (18).

COMMUNITY HEALTH CONCERNS

A public meeting was held February 22, 2001, and a Community Advisory Group meeting was held on September 24, 2002, for the Riverfront site in New Haven, Missouri. Community members voiced several health concerns and questions that are addressed below.

On October 30, 2003, DHSS held a public availability session to present the public comment version of the Riverfront (a/k/a New Haven Public Water Supply) Public Health Assessment to the public and to gather and discuss any additional concerns the public might have. No additional health concerns were presented in person at the public availability session or received in the mail. Some technical comments were received during the public comment period and are addressed in Appendix E.

1. Why are private wells being tested? What does the process of having my well tested entail? How long will it take to get back the results?

   EPA, USGS, and DHSS are sampling private wells to determine if they are contaminated with PCE. PCE contamination has been detected in the city of New Haven's wells No. 1 and No. 2, which has been taken off-line (1). Those residents on the public water system are currently being supplied water from two uncontaminated wells, city wells No. 3 and No. 4. The aquifer that supplies city wells No. 1 and No. 2 may also supply private wells in the area. DHSS considers it a priority that the private wells in the direction(s) of suspected PCE contamination plume(s) around the city limits of New Haven be monitored to ensure that no one is drinking, bathing, or cooking with contaminated water. The water should be analyzed for several volatile organic compounds, which include PCE and its breakdown products. Hopefully, wells are not contaminated, but in the event contamination is found in a well, safe practice recommendations will be made. This sampling is free of charge and confidential. A copy of the sampling results, as well as a letter explaining those results, will be supplied to the resident within four to six weeks. Contact the Missouri Department of Health and Senior Services, Section for Environmental Public Health at 1-866-628-9891 for more information about well testing.

2. Is a high level of PCE contamination in the water a possible health hazard only if you drink it, or does it also apply to all water use (i.e., bathing, showering, and cooking, etc.)?

   In addition to ingestion (drinking), inhalation is a significant exposure pathway when potable water is contaminated with volatile organic compounds. Studies have shown that volatilization of contaminants during bathing, showering, cooking, dishwasher's washing, rinsing, and drying cycles release contaminants into the indoor air of a home where they can be inhaled. Dermal contact with the PCE contaminated groundwater is not expected to be a health concern at this site.

3. The Leader newspaper referenced a few sites in town that had varying levels of PCE found. I am concerned about and would like to know information on the levels found at the New Haven Elementary School.

   Because the school is on the New Haven Public Water System, the school's drinking water is not contaminated.

4. The Leader also stated that long-term or chronic exposure to high levels of PCE has been linked to kidney and liver ailments as well as neurological effects. Could I please be provided more information on the subject of these possible ailments, effects, or incidence levels?

   PCE is considered a weak liver toxin based on reports of human exposure. Most reported cases

are due to accidental exposures or deliberate abuse of unknown dose and duration. PCE should also be considered a possible kidney toxin in humans, but weak or no kidney effects were reported in people with chronic (long term) occupational exposure. Adverse kidney, liver, and neurological effects are not expected from exposure to the level of PCE contamination found in drinking water at the site (18).

5. Does PCE cause or contribute to the cause of Multiple Sclerosis (MS)? It seems like there are more people in New Haven that have MS than in other nearby towns. Is anyone looking into this?

   The exact cause of Multiple Sclerosis (MS) is unknown, and there is no literature or studies that suggest a relationship between MS and PCE. The Missouri Department of Health and Senior Services does not collect data on MS; therefore the prevalence of MS in Missouri is difficult to determine. Efforts are being made within the department to track and collect data on the prevalence of a number of different chronic diseases, including MS, in the future. The Agency for Toxic Substances and Disease Registry (ATSDR) is currently conducting studies in various states including Texas, Ohio, and Missouri regarding MS and hazardous waste. At this time, the studies in Missouri are not looking at the relationship between MS and PCE and would not include New Haven residents.

6. One of my parents worked with PCE in an industrial setting, what health effects might be expected to occur?

   Because it is not known what levels of PCE your parent was exposed to, the duration of that exposure, or how PCE exposure affects a certain individual, we cannot determine what health effects may occur. Most occupational exposure results from inhalation of PCE. If levels are expected to be elevated, industries should have measures in place to limit exposure to below the Occupational Safety and Health Administration (OSHA) regulated levels and may also provide medical monitoring to protect workers. If they feel their health have been affected by the exposure, they should contact their physician.

   Exposure to PCE can occur in the workplace, near hazardous waste sites, and from certain consumer products, including clothes that have been dry-cleaned. Central nervous system effects (headaches, dizziness, difficulty in speaking, and sleepiness) are the most predominant effects found during a study of exposure to high levels (100,000 ppb) of PCE for seven hours. Limited studies of women who work in the dry cleaning industries, where exposure to PCE can be quite high, may have more menstrual and spontaneous abortions than women who are not exposed. In animal studies with amounts much higher than most people are exposed to, results provide evidence that PCE can cause liver and kidney damage as well as cancer to these organs, but the relevance to humans is unclear (18).

CONCLUSIONS

Based on the discovery of tetrachloroethylene (PCE) contamination in the city of New Haven's public wells in 1986, users of the public water system were exposed to PCE-contaminated drinking water above EPA's MCL until 1993 when the last contaminated well was taken offline. Currently, there is no known exposure to PCE in drinking water above the MCL or to subsurface contaminated soils. Based on the review of available data we conclude that past and current exposures pose No Apparent Public Health Hazard. The category of No Apparent Public Health Hazard is used for sites where human exposure to a contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard.

The Riverfront site has been classified as an Indeterminate Public Health Hazard for the future, because PCE contamination is still present in the area's groundwater and subsurface soils. Additionally, it is unknown if

PAHs and lead are present in a small area of surface soil in OU-1. The category of Indeterminate Public Health Hazard is used for sites for which no conclusions about public health hazard can be made because data is lacking. This classification is based on the following considerations:

1. Potential exposure pathways to PCE-contaminated groundwater and soil currently exist and may exist in the future. If exposure occurred, it could be at levels of health concern, especially for children and sensitive individuals.

2. Data gaps about the potential source(s) of PCE contaminated groundwater and its movement makes it difficult to determine if future exposure pathways will occur in the New Haven area.

3. High levels of PCE contamination remain in subsurface soils and groundwater which workers or residents could be exposed to if digging at depth.

4. PCE in groundwater and subsurface soils may move up through the soil and into residences located on contaminated areas. Additionally, PCE may volatilize from contaminated well water. Inhalation of volatilized PCE may be of health concern in the future.

5. Levels of PCE detected in small surface streams should not pose a health concern unless the levels increase dramatically and/or the water is used for drinking.

6. The possibility exists that black plastic polyethylene water lines may run through PCE contaminated areas and exposing residents who are supplied water through that line.

7. In an area across from the Wiser building, there are indications that recreational activities may be taking place where elevated levels of lead and polycyclic aromatic hydrocarbons (PAHs) in subsurface soil (1.5 to 2.0 feet) has been found, but the surface soil (0-3 inches) has not been sampled to determine if levels of a health concern exist.

RECOMMENDATIONS

1. Continue to monitor the municipal water supply and private wells in the area to ensure that people are not drinking contaminated water.

2. Continue to take necessary actions to eliminate exposure pathways to PCE-contaminated groundwater or other source(s) when discovered.

3. Continue to determine where source areas are located that are contributing to groundwater contamination and remediate appropriately.

4. Continue to quantify levels of soil and groundwater contamination so that the proper health recommendations can be made, if necessary.

5. Determine interior air levels of PCE at residences most susceptible, to determine if a health concern exists.

6. Workers digging in contaminated subsurface soils should take precautions to prevent exposure.

7. Determine if black plastic polyethylene water lines run through areas of contaminated soil or groundwater and remediate appropriately.

8. Sample surface soil in the area of subsurface lead and PAH contamination to determine if the area has surface soil contamination at a level of health concern.

PUBLIC HEALTH ACTION PLAN

This Public Health Action Plan (PHAP) for the Riverfront site contains a description of actions to be taken by the Missouri Department of Health and Senior Services (DHSS), the Agency for Toxic Substances and Disease Registry (ATSDR), and others. The purpose of the PHAP is to ensure that this public health assessment not only identifies public health hazards, but provides an action plan to mitigate and prevent adverse human health effects resulting from past, present, and future exposures to hazardous substances at or near the site. Below is a list of commitments of public health actions to be implemented by DHSS, ATSDR or other stakeholders at the site:

1. DHSS/ATSDR will review information pertaining to the Riverfront site as it becomes available. Appropriate public health recommendations will be made at that time, as necessary.

2. DHSS/ATSDR will coordinate with the appropriate environmental agencies to implement the recommendations in this public health assessment.

3. DHSS/ATSDR will continue to address community health concerns and questions as they arise and provide necessary community and health professional education.

4. DHSS/ATSDR/EPA/USGS will continue to monitor private wells near the Riverfront site to insure that private wells owners have safe drinking water.

5. EPA has indicated that they will sample indoor air in various residences and industries to determine if PCE contamination is present. DHSS/ATSDR will assist EPA to determine if the levels detected are of a health concern.

6. DHSS/USGS/City of New Haven will continue to investigate if black plastic polyethylene water lines run through areas of contamination and determine if the water is being affected.

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CERTIFICATION

The Riverfront (a/k/a New Haven Public Water Supply) Public Health Assessment was prepared by the Missouri Department of Health and Senior Services under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved methodology and procedures' existing at the time the public health assessment was initiated.

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The Superfund Site Assessment Branch of the Division of Health Assessment and Consultation, ATSDR, has reviewed this public health assessment and concurs with its findings.

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APPENDICES

APPENDIX A: GLOSSARY OF TERMS AND ACRONYMS USED IN THE RIVERFRONT PUBLIC HEALTH ASSESSMENT

Acute Exposure:

Contact with a chemical that happens once and only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.

Additive Effect:

A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

Adverse Health Effect:

A change in body function or the structure of cells that can lead to disease or health problems.

ATSDR:

The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.

Cancer:

A group of diseases, which occur when, cells in the body become abnormal and grow, or multiply, out of control.

CERCLA:

See **C**omprehensive **E**nvironmental **R**esponse, **C**ompensation, and **L**iability **A**ct.

Chronic Exposure:

A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be *chronic*.

Completed Exposure Pathways:

See Exposure Pathways.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA):

CERCLA was put into place in 1980. It is also known as **Superfund**. This act concerns releases of hazardous substances into the environment, and the cleanup of these substances and hazardous waste sites. ATSDR was created by this act and is responsible for looking into the health issues related to hazardous waste sites.

Concern:

A belief or worry that chemicals in the environment might cause harm to people.

Concentration:

How much or the amount of a substance present in a certain amount of soil, water, air, or food.

Contaminant:

See Environmental Contaminant.

DHSS:
Missouri Department of Health and Senior Services

Degradation:
The reduction of a chemical compound to one less complex.

Dermal Contact:
A chemical getting onto your skin. (See **Route of Exposure**)

Environmental Contaminant:
A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than that found in **Background Level**, or what would be expected.

Environmental Media:
Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.

U.S. Environmental Protection Agency (EPA):
The federal agency that develops and enforces environmental laws to protect the environment and the public's health.

Exposure:
Coming into contact with a chemical substance. (For the three ways people can come in contact with substances, see **Route of Exposure**.)

Exposure Pathway:
A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical.

ATSDR defines an exposure pathway as having 5 parts:

1. Source of contamination,
2. Environmental Media and Transport Mechanism,
3. Point of Exposure,
4. Route of Exposure, and
5. Receptor Population.

When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.

Hazardous Waste:
Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

Health Effects:
ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).

Hydrogeology:
The study of groundwater with particular emphasis on the chemistry and movement.

Indeterminate Public Health Hazard:
The category is used in Public Health Assessment documents for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures.

Ingestion:
Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (See **Route of Exposure**).

Inhalation:
Breathing. It is a way a chemical can enter your body (See **Route of Exposure**).

Karst:
An area of irregular limestone in which erosion has produced fissures, sinkholes, underground streams, and caverns.

MCL:
Maximum **C**ontaminant **L**evel. The highest level of a contaminant that EPA allows in public drinking water. MCLs ensure that drinking water does not pose either a short-term or long-term health risk. EPA sets MCLs at levels that are economically and technologically feasible.

MRL:
Minimal **R**isk **L**evel. An estimate of daily human exposure - by a specified route and length of time - - to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predicator of adverse health effects.

mg/Kg/day:
A measurement of exposure in milligram (mg) of a chemical per Kilogram (Kg) of body weight per day.

NPL:
The **N**ational **P**riorities **L**ist. (Which is part of **Superfund**.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious, uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.

NOAEL:

No **O**bserved **A**dverse **E**ffect **L**evel. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.

No Apparent Public Health Hazard:
The category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposure is below a level of health hazard.

No Public Health Hazard:
The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.

PHA:
Public **H**ealth **A**ssessment. A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.

Plume:
A line or column of air or water containing chemicals moving from the source to areas further away. A plume can be a column or clouds of smoke from a chimney or contaminated underground water sources or contaminated surface water (such as lakes, ponds, and streams).

Point of Exposure:
The place where someone can come into contact with a contaminated environmental medium (air, water, food, or soil). For examples: the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, the location where fruits or vegetables are grown in contaminated soil, or the backyard area where someone might breathe contaminated air.

Population:
A group of people living in a certain area; or the number of people in a certain area.

Potential Exposure Pathway:
An exposure pathway with at least one of the five elements missing for a completed exposure pathway, but the potential exists for that element to be added allowing for exposure to a contaminant.

ppb:
Parts per billion = One part of chemical/pollutant per a billion parts of water.

ppm:
Parts per million = One part of chemical/pollutant per a million parts of water.

PRP:
Potentially **R**esponsible **P**arty. A company, government, or person that is responsible for causing the

pollution at a hazardous waste site. PRP's are expected to help pay for the clean up of the site.

Public Health Assessment(s):
See **PHA.**

Public Health Hazard:
The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Public Health Hazard Criteria:
PHA categories given to a site which tell whether people could be harmed by conditions present at the site. Each are defined in the Glossary. The categories are:
- Urgent Public Health Hazard
- Public Health Hazard
- Indeterminate Public Health Hazard
- No Apparent Public Health Hazard
- No Public Health Hazard

Receptor Population:
People who live or work in the path of one or more chemicals, and who could come into contact with them (See **Exposure Pathways**).

Route of Exposure:
The way a chemical can get into a person's body. There are three exposure routes:
- breathing (also called inhalation),
- eating or drinking (also called ingestion), and
- or getting something on the skin (also called dermal contact).

Source (of Contamination):
The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.

Sensitive Populations:
People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Superfund Site:
See **NPL**.

Toxicology:
The study of a harmful effects of chemicals on humans or animals.

USGS:
U.S. Geological Survey.

Urgent Public Health Hazard:
This category is used in ATSDR's Public Health Assessment documents for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require quick intervention to stop people from being exposed.

Volatile Organic Compound:
An organic (carbon-containing) compound that evaporates (volatilizes) readily at room temperature.

APPENDIX B: MAPS

Figure 1. Riverfront Site Location Map

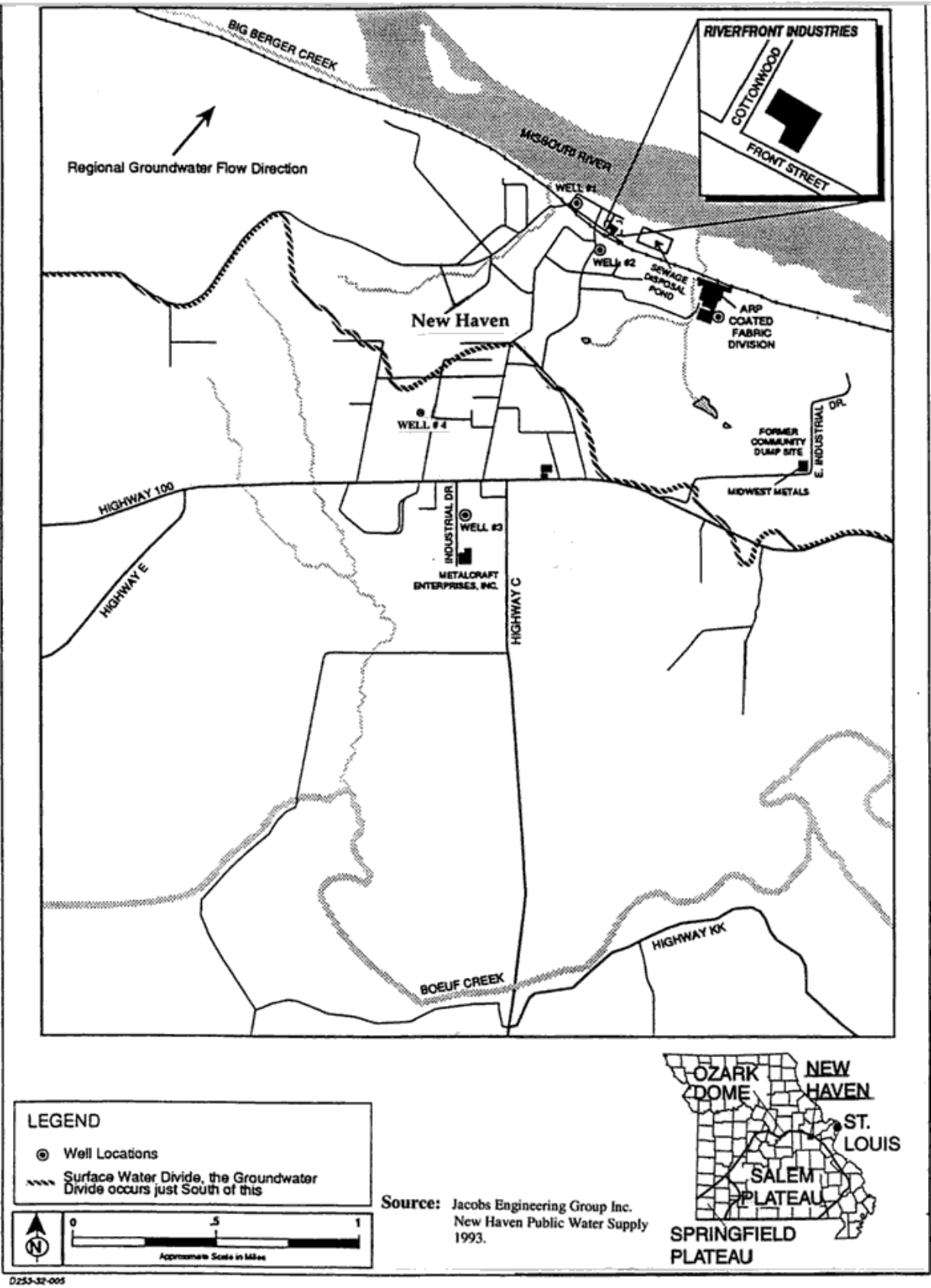
Figure 2. Location of Operable Units at Riverfront Site

APPENDIX C: EXPOSURE PATHWAYS TABLE

Pathways Name	Exposure Pathways Elements					Time	Type of Pathways
	Source	Environmental Media	Point of Exposure	Route of Exposure	Exposed Population		
Groundwater	PCE Contaminated Groundwater	Groundwater	Residents Connected to New Haven Public Water	Ingestion Inhalation Dermal Contact	New Haven Public Water Users	Past	Completed
Groundwater	PCE Contaminated Groundwater	Groundwater	Private Well Owners Above MCL	Ingestion Inhalation Dermal Contact	Private Well Users	Past	Completed
Groundwater	PCE Contaminated Groundwater	Groundwater	Private Well Owners Below MCL	Ingestion Inhalation Dermal Contact	Private Well Users	Past, Present, & Future	Completed

Figure 1

Riverfront Site Location Map

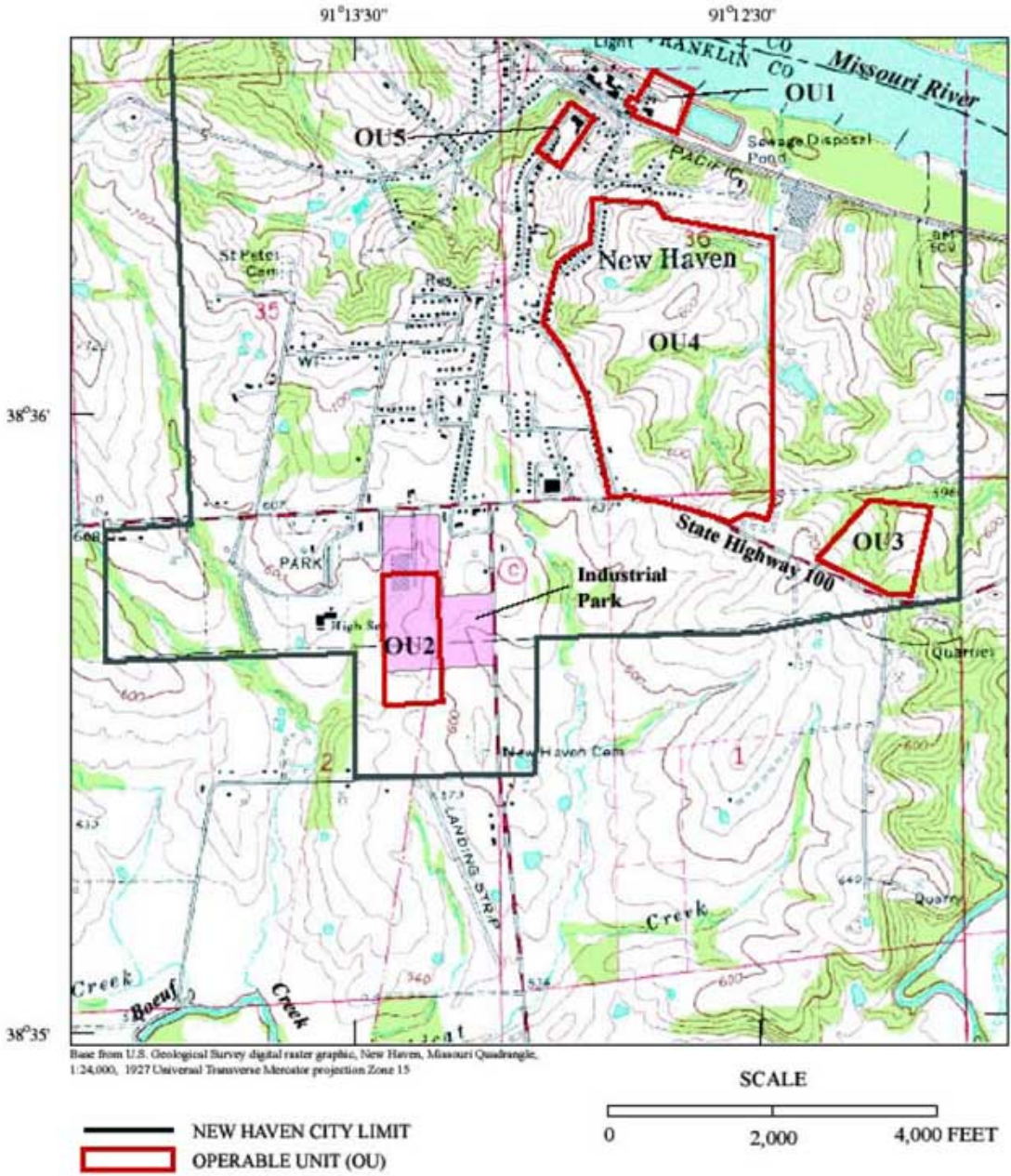


Source: Jacobs Engineering Group Inc. New Haven Public Water Supply 1993.

D253-32-005

Figure 2

Location of Operable Units (OUs) at Riverfront Site New Haven, Franklin County, Missouri



Source: U.S. Environmental Protection Agency, Region VII. Focused Remedial Investigation of Operable Units OU1 and OU3, Riverfront Superfund Site Franklin County, Missouri. 2003

Soil	Contaminated Soil	Soil	Areas of Contaminated Soil	Ingestion Inhalation Dermal Contact	Workers and Residents Digging in Contaminated Soil	Past, Present, & Future	Potential
Air	PCE Contaminated Groundwater	Indoor Air	Residences over PCE Contamination Plume	Inhalation	Residents living over PCE Contamination Plume	Past, Present, & Future	Potential
Groundwater	PCE Contaminated Groundwater	Groundwater	Residents Connected to New Haven Public Water	Ingestion Inhalation Dermal Contact	New Haven Public Water Users	Future	Potential
Surface Stream	PCE Contaminated Groundwater	Surface Water	Stream	Ingestion Inhalation Dermal Contact	Stream Users	Past, Present, & Future	Potential
Water Supply	PCE Contaminated Water or Soil	Contaminated Groundwater or Soil	Residences using Black Plastic Water Lines	Ingestion Inhalation Dermal Contact	Residents with Black Plastic Water Lines through Contamination	Past, Present, & Future	Potential

APPENDIX D: EXPOSURE CALCULATIONS

Click here to view Appendix D in PDF format (PDF, 24KB)

APPENDIX E: SUMMARY OF COMMENTS RECEIVED ON THE PUBLIC COMMENT VERSION OF THE RIVERFRONT (a/k/a NEW HAVEN PUBLIC WATER SUPPLY) PUBLIC HEALTH ASSESSMENT

Comments:

1. The public health assessment doesn't follow EPA guidelines for risk assessments.

   The public health assessment (PHA) is a document designed to inform the public about hazardous waste sites and how the site may have affected them. Although, the PHA uses the same data and similar procedures as the EPA risk assessment, its audience is different and it is written in accordance with the procedures of the ATSDR Public Health Assessment Guidance Manual.

2. The characterization of cancer risks from past exposure to contaminated groundwater is inconsistent with EPA risk assessment guidance and is unnecessary since actions were already taken tomitigate those exposures and associated risks. Also, the PHA uses concentrations and durations of past exposures that are not exact and may overestimate the risks.

   The purpose of the public health assessment (PHA) is to inform the public about the site, determine their exposure to the contaminants from the site and potential adverse health effects from that exposure, and recommend ways to prevent or lessen further exposure. Remediation has taken place at the site to eliminate exposure to certain pathways (e.g. public drinking water), but residents were exposed prior to remediation. The PHA discusses past, present, and possible future exposures to inform the public if any adverse health effects are expected. When actual

exposure levels are not known, the PHA develops a worst-case exposure scenario using available contaminant concentrations and exposure durations that residents were exposed to as per the ATSDR Public Health Assessment Guidance Manual.

3. The PHA summary briefly mentions the potential for the subsurface vapor intrusion pathway, but no discussion is provided on this pathway in the potential exposures pathways section.

   The PHA discusses the possible vapor intrusion pathways of PCE contamination into residences in the Summary and Background sections and a discussion has been added to the Discussion section under Potential Exposure Pathways.

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Appendix D:

Exposure Calculations

Exposure Calculations

Non-Cancerous:

Past Ingestion Exposure from PCE in public drinking water

The maximum level of PCE detected from city well No. 2 that users may have been exposed to for a period of time is considered to be 89 ppb.

$$\text{Ingestion Exposure Dose} = \frac{C \times IR \times EF}{BW}$$

where:
C = contaminant concentration (mg/L)
IR = ingestion rate
EF = Exposure Factor
BW = body weight

Adult: (89 ppb = 0.089 ppm = 0.089 mg/L)
This calculation assumes that an adult weighs 70 Kg and drinks 2 L of tap water per day.

$$\text{Ingestion Exposure Dose} = \frac{0.089 \text{ PCE mg/L} \times 2 \text{ L/day water} \times 1}{70 \text{ kg}}$$

Ingestion Exposure Dose = 0.0025 mg/Kg/day

Child:
This calculation assumes that a child weighs 10 Kg and drinks 1 L of tap water per day.

$$\text{Ingestion Exposure Dose} = \frac{0.089 \text{ PCE mg/L} \times 1 \text{ L/day water} \times 1}{10 \text{ Kg}}$$

Ingestion Exposure Dose = 0.0089 mg/Kg/day

Past Ingestion Exposure from PCE in private wells:

Users of PCE contaminated private wells are assumed to have been exposed to 210 ppb of PCE for a 12-year period of time. It is not likely that private well users were exposed at this level or for this period of time, but these assumptions are made to develop a worst-case exposure scenario.

Adult: (210 ppb = 0.210 ppm = .021 mg/L)

$$\text{Ingestion Exposure Dose} = \frac{0.210 \text{ PCE mg/L} \times 2 \text{ L/day water} \times 1}{70 \text{ Kg}} =$$

Ingestion Exposure Dose = 0.006 mg/Kg/day

Child:

$$\text{Ingestion Exposure Dose} = \frac{0.210 \text{ PCE mg/L} \times 1 \text{ L/day water} \times 1}{10 \text{ Kg}} =$$

Ingestion Exposure Dose = 0.021 mg/Kg/day

Total Past Exposure for PCE in Drinking Water (Ingestion and Inhalation Exposure)

Because the user of a PCE contaminated water supply would also have exposure through inhalation as PCE volatilizes into the air, inhalation exposure must be included as part of the exposure. Most of this inhalation exposure takes place during and after showering as time spent in the bathroom. To consider both pathways of exposure and their additive effect, we double the ingestion exposure dose for a conservative (more protective) value to include both pathways.

Total Past Public Drinking Water Exposure

Total Adult Exposure Dose: 0.0025 mg/Kg/day x 2 = 0.0050 mg/Kg/day

Total Child Exposure Dose: 0.0089 mg/Kg/day x 2 = 0.0178 mg/Kg/day

Total Past Private Well Exposure

Total Adult Exposure Dose: 0.006 mg/Kg/day x 2 = 0.012 mg/Kg/day

Total Child Exposure Dose: 0.021 mg/Kg/day x 2 = 0.042 mg/Kg/day

ATSDR's Acute (14 days or less) ingestion MRL for PCE = 0.05 mg/Kg/day.
ATSDR has not derived an intermediate (15-364 days) ingestion exposure MRL for PCE.
ATSDR has not derived a chronic (365 days or more) ingestion exposure MRL for PCE.

Cancer:

Using the assumption that PCE is carcinogenic, even though it is under review by EPA as to its carcinogenicity, the following calculation is used to approximate its theoretical risk if it would be determined to be carcinogenic in humans. Calculations assume that users of the New Haven public water supply were exposed at the maximum level of PCE contamination (89 ppb) for seven years.

Formula:

$$\text{Cancer Risk} = \frac{\text{Exposure dose x risk factor x years exposure}}{\text{70 years (lifetime)}}$$

Public Drinking Water Cancer Risk:

(Risk factor = 0.052 EPA's Oral Slope Factor)

$$\textbf{Adult Cancer Risk} = \frac{0.0050 \text{ mg/Kg/day} \times 0.052 \text{ (mg/Kg/day)}^{-1} \times 7 \text{ years}}{70 \text{ years}} =$$

Adult Cancer Risk = 0.000026 = 2.6 x 10^{-5}

$$\textbf{Child Cancer Risk} = \frac{0.0178 \text{ mg/Kg/day} \times 0.052 \text{ (mg/Kg/day)}^{-1} \times 7 \text{ years}}{70 \text{ years}} =$$

Child Cancer Risk = 0.000093 = 9.3 x 10^{-5}

Note : A child is considered a child for only 6 years so this cancer risk calculation overestimates the child's cancer risk.

Private Well Water Cancer Risk:

Calculations assume that private well users were exposed to PCE contaminated well water at a level of 210 ppb for a period of 12 years to develop a worst-case exposure scenario.

$$\textbf{Adult Cancer Risk} = \frac{0.012 \text{ mg/Kg/day} \times 0.052 \text{ (mg/Kg/day)}^{-1} \times 12 \text{ years}}{70 \text{ years}} =$$

Adult Cancer Risk = 0.00011 = 1.1 x 10^{-4}

$$\textbf{Child Cancer Risk} = \frac{0.042 \text{ mg/Kg/day} \times 0.052 \text{ (mg/Kg/day)}^{-1} \times 12 \text{ years}}{70 \text{ years}} =$$

Child Cancer Risk = 0.00037 = 3.7 x 10^{-4}

Note : A child is considered a child for only 6 years so this cancer risk calculation overestimates the child's cancer risk.